Avnet / Texas Instruments Low-Power RF Workshop

Lab Procedures

Lab 1 - Exploring TI's eZ430 Chronos kit: wireless aspects of provided CC430 Projects

Lab 2 - Chronos2Chronos Communication, SmartRF Studio and RSSI Power Meter

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Version 1.3

Revision History

Version	Description	Date
1.0	Initial release	7/13/2011
1.1	Updates based on initial feedback from Denver	7/26/2011
1.2	Changes to Lab1 procedure after Denver workshop	8/03/2011
1.3	Changes to Lab1 procedure after Wisconsin workshop	8/11/2011

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Overview

These labs commence with a quick overview of the eZ430 Chronos Eval Kit, it's CC430 (microcontroller + RF transceiver), the software tools and RF Networking protocols utilized (SimpliciTI, BlueRobin, RFBSL)

Lab1 steps users through a hands-on exploration of features and operation of eZ430 Chronos kit with focus specifically on the wireless communication aspects of the provided Open Source Projects

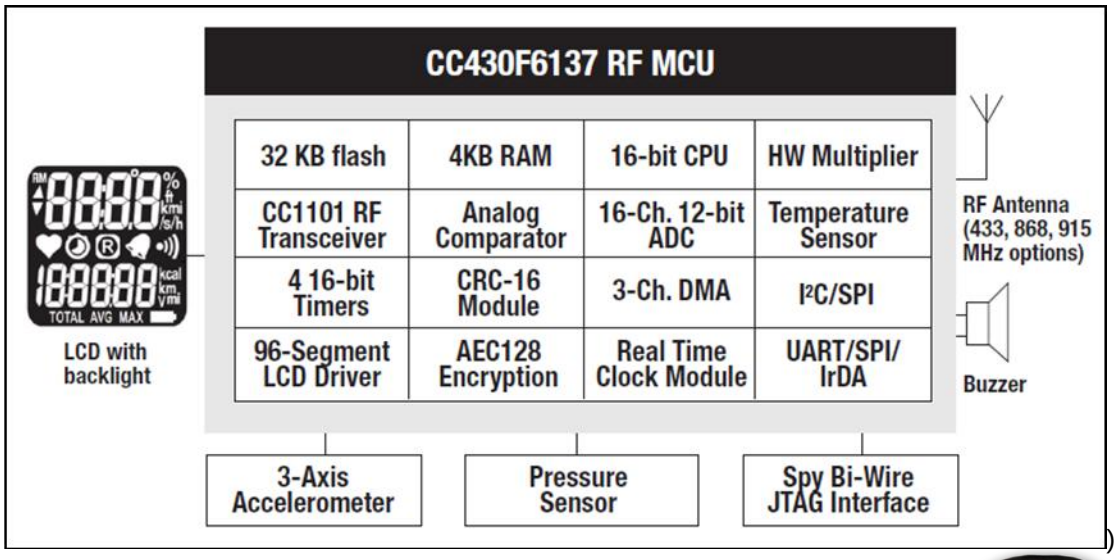
Lab 2A: Firmware re-compile for Chronos2Chronos (peer to peer) communication

Lab 2B: Use of SmartRF Studio to re-configure CC430 RF settings

Lab 2C: Implement a simple RSSI power-meter application on Chronos

Lab 3 : Instructor led demos
a) Chronos as an accelerometer-based remote-control directing the motor-control drive- and steering of a mobile Stellaris (ARM Cortex-M3 EvalBot board.

b) Android based Bluetooth messaging to a Fossil MetaWatch



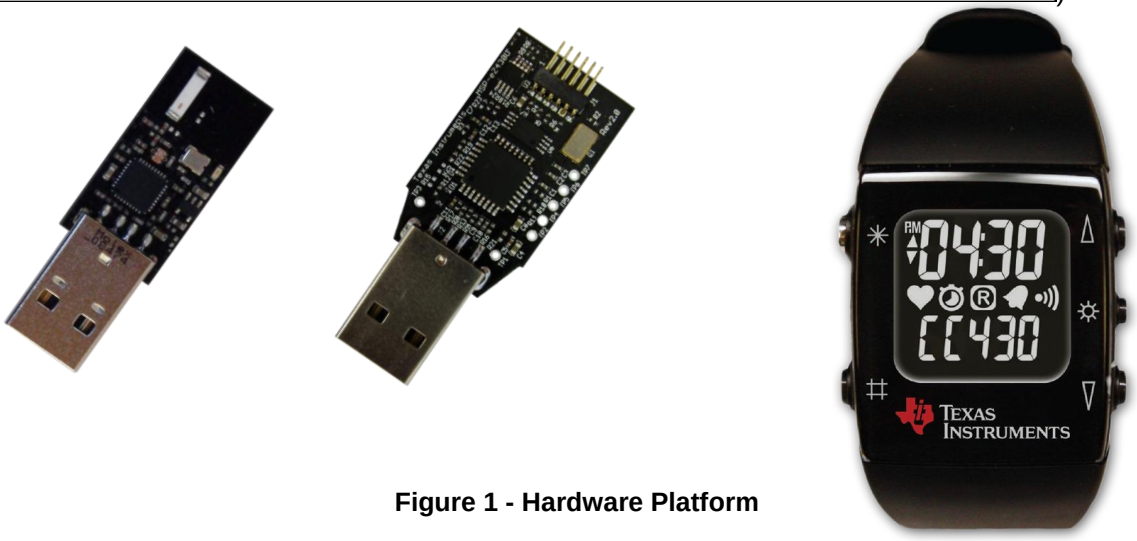


Figure 1 - Hardware Platform

Objectives

Gain practical hands-on experience working with devices from TI's LPRF portfolio
ie. **CC430F6137** (on Chronos), **CC1111** (on RF Gateway), **CC1101** (on EvalBot)

Exposure to a subset of the available TI tools:
Code Composer Studio (CCS4), eZ430-Chronos, SmartRF Studio7 as well as 5 example applications:
(Chronos Sports Watch, Chronos DataLogger, Chronos2Chronos, Chronos RSSI and Chronos Drive)

Getting Started - What you need

Hardware:

a) Laptop Computer (Attendee responsibility!): running MS Windows XP or Windows-7
(ideally with 2 USB ports available)

b) eZ430-Chronos Development Tool Kit (Avnet will provide), part# **EZ430-CHRONOS-915**
(includes USB-based Access Point and USB-based Programmer/Debugger)

Software:

c) eZ430-Chronos Software Package
Download latest version from the provided link and install on Laptop PC
(Do not install from the CD that came with the kit!) :
Windows (SLAC341)
Note: It is recommended Windows display DPI configuration is for "normal" (100%) font-size.

d) Compiler/Debugger IDE (install on laptop PC):
CCS4 (Note: must be the Platinum, node-locked version, but only support for MSP430 family needs to be loaded. Activate the 30-day license by going to:
http://tiexpressdsp.com/wiki/index.php?title=Activating_CCS
then follow the step-by-step instructions on that page…

e) Lab 2 Chronos2Chronos and RSSI Project Files
(Accessed from Customer Pre-Work email /or FAE access to Avnet Sharepoint,
also available at workshop on USB Thumb-drive)
Unzip to **C:\TEMP** folder for now

f) Firmware Update tool (optional, standalone tool from BMI for adding rfBSL updates)
eZ430-Chronos Watch Firmware Update Tool

g) TI's Smart RF Studio 7 Software Tool (install on laptop PC)
SmartRF Studio 7 v1.5.0

Documentation (only for reference as needed):

- eZ430-Chronos User Guide (SLAU292):
  Technical details and instructions for Chronos (is included in eZ430-Chronos software install)
- CC430 User Guide: Technical user manual for CC430
- CC430F613x Datasheet: Electrical specs for CC430F613x

Lab1: Exploring Chronos Functionality & Features

Lab 1 - Exploring TI's eZ430 Chronos kit: Wireless aspects of the provided CC430 Projects

Caution! The RF Access Points are factory-set to transmit **on the same frequency**.
Lab1 requires careful management of workshop attendees to ensure only one Access Point and Chronos is enabled / transmitting at a given time, especially when doing the following:
- synchronizing (eg. setting Date & Time, Temp & Altitude calibration,etc) Chronos to the Laptop, and
- when executing RFBSL over the air firmware updates

Symptoms to look-out for of more than one Chronos or Access Point transmitting are:
- jerky/slowed updates of the displayed XYZ accelerometer readings
- failure to set the time from laptop, failure of RFBSL over the air firmware updates

(This not an issue for Lab2 where communication is peer to peer with different frequency channels allocated to pairs of workshop attendees).

1) Test-drive the default "Chronos Sports Watch" App as shipped in standalone mode, using '*' and '#' buttons to navigate the 2 sets of menus. (Instruction card inside the box your eZ430 Chronos arrived in as well as Figure 2 below provide guidance on this…)

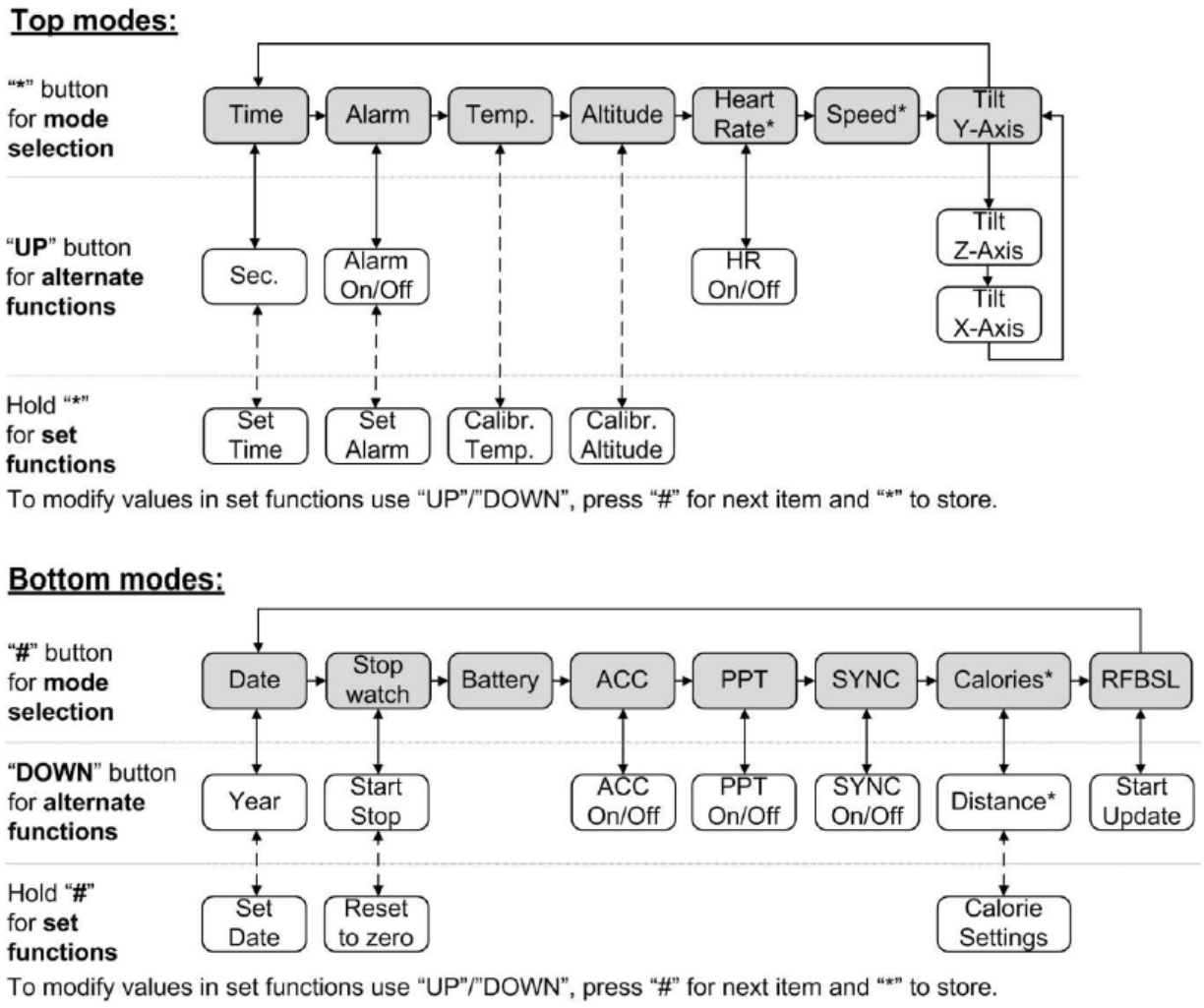


Figure 2 - eZ430-Chronos Feature Overview and Menu Structure

Lab1: SimpliciTI transmission of Accelerometer data

During the course of these labs hardware drivers will be installed for both the provided USB "dongles":
a) **eZ430 Chronos RF Access Point**
b) **eZ430 Debug Interface**
*The USB drivers are included in the eZ430-Chronos installer package. Windows USB driver installation is described in detail in **Appendix B** (pages 96 to 101) of the **eZ430 Chronos User Guide**).

1) Install the supplied eZ430-Chronos RF Access Point dongle into one of your laptop USB ports. If this is the first time it is being inserted, the Device Driver Installation Wizard window will appear on the screen. Complete this install wizard as detailed in **Appendix B of the eZ430 Chronos User Guide**.

2) On Laptop: launch the Chronos Control Center (Programs →Texas Instruments → ez430-Chronos), select SimpliciTI Acc tab, then click "Start Access Point"

3) On Chronos: Use '#' button to get to "ACC" mode (lower line of Chronos LCD)
Follow direction from class Instructor as to when you can activate data transmission using the "DOWN" button

4) On Laptop (one at a time): Live XYZ accelerometer data will be displayed with smooth updates of XYZ data as Chronos is moved around.

5) On Laptop (now with multiple units transmitting): Live XYZ accelerometer screen updates are now very intermittent as conflicts occur between the transmissions from multiple Chronos units

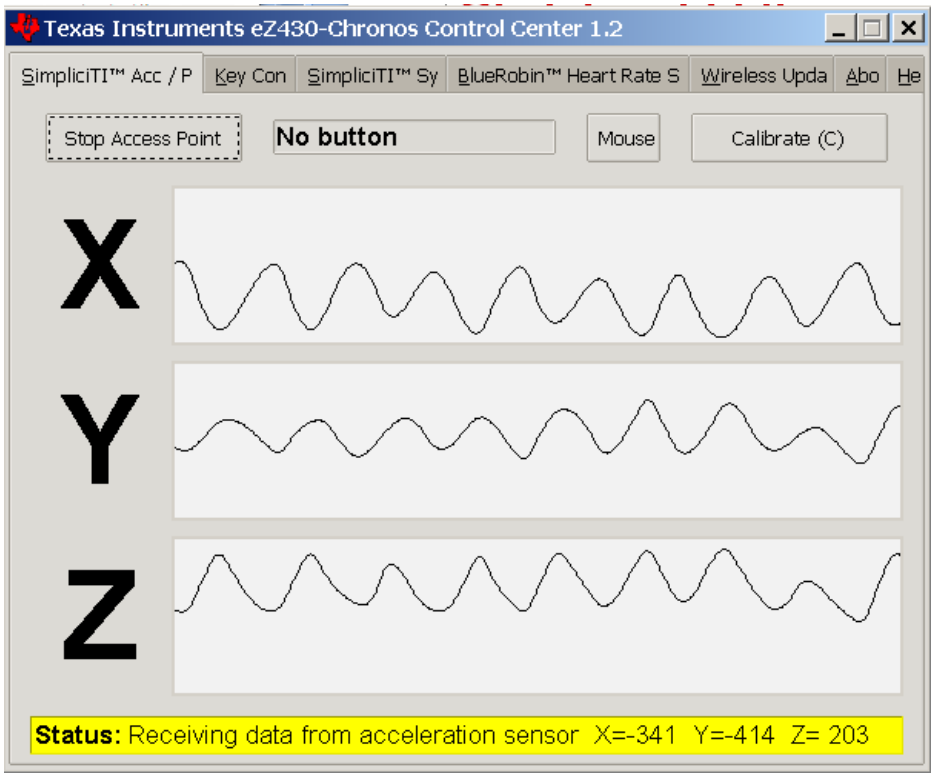


Figure 3 - eZ430-Chronos Control Center with Acceleration Data

Lab1: BlueRobin RF reception of Heart-Rate & Speed

(displays on both PC and Chronos)

6) On Laptop: in **Chronos Control Center** select "**BlueRobin Heart Rate Sim**" tab, check "**Sweep Heart Rate**", "**Sweep Speed**" and "**km/h**"
then click "**Start Transmitter**"

7) On Chronos: Use the "*****" button to advance to Heartrate ("♥") mode,
then press the "**Up**" button to enable data reception

8) On Chronos: Simulated Heartrate is displayed on **upper line of LCD**

9) On Chronos: press "*****" once more to display Speed (mph or km/h)

10) When finished, use the "*****" button to cycle through to Heartrate ("♥") mode again then press "**Up**" button once more to disable Blue Robin reception

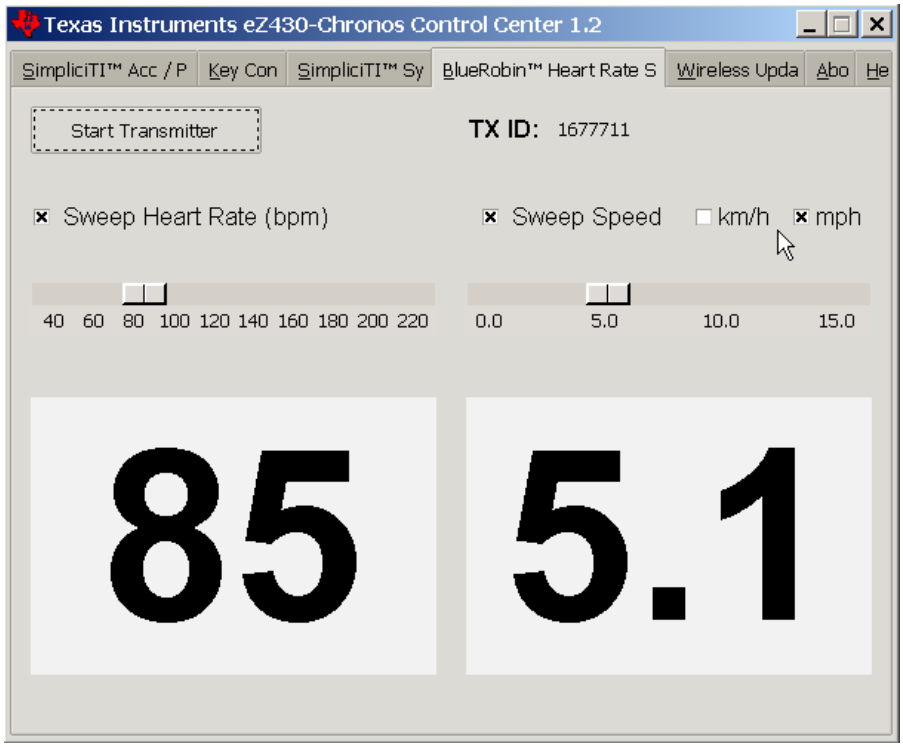


Figure 4 - eZ430-Chronos Control Center Heart Rate Simulator

Figure 5 - Detail of Chronos control buttons and LCD

Lab1: RFBSL Wireless Firmware Update

(downloading the Datalogger application)

11) On Laptop: In Chronos Control Center select Wireless Update, then Browse to
C:\Program Files\Texas Instruments\eZ430-Chronos\Recovery\Chronos Watch\Applications
Select **Recovery_ez430_chronos_datalogger_915MHz.txt**
On Laptop: Click Update Chronos Watch

Attention! - Multiple Chronos updates transmitted at the same time will likely result in update errors! In the interest of completing the labs in the allocated time, steps 12 through 29 should be done only by the instructor !
ie. The remainder of Lab1 ***is performed by the Instructor only!*** *Workshop attendees follow the procedure in their notes but do not re-flash their Chronos units to the Datalogger application*.

12) Instructor: Press "**#**" button until "**rFbSL**" is displayed
Instructor: Press Down button: "**ConF**" is displayed (/may be absent if older Chronos firmware)
Instructor: Press Down button again to confirm and commence the firmware update…

13) On Chronos: "**rAN**" will display briefly, followed by an incrementing **nn%** progress indicator on top line of LCD, "**dLog**" then displays on lower line after completion (may need button press to wake display).

14) On Laptop: Close the Chronos Control Center app.

15) On Laptop: Launch the Chronos DataLogger application
(Start → Programs → Texas Instruments → eZ430-Chronos → Chronos DataLogger)
The SimpliciTI Sync tab facilitates setting time/date and calibration of sensors as well as readback of the logged data from Chronos datalogger memory.

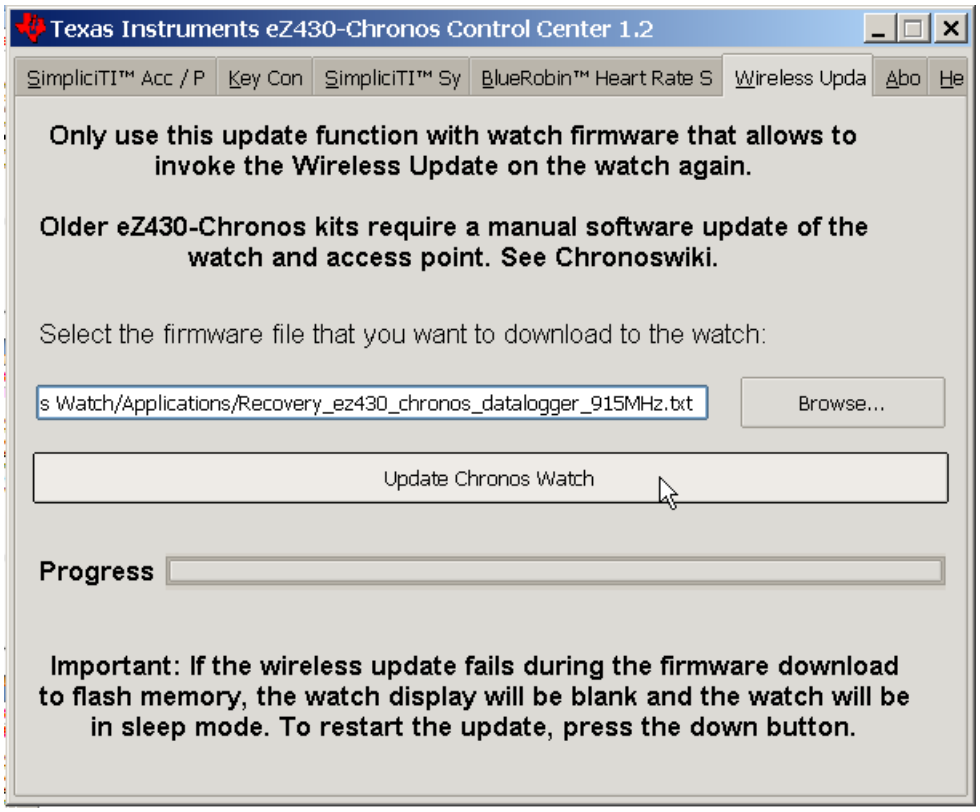

Texas Instruments eZ430-Chronos Control Center 1.2
SimpliciTI™ Acc / P
Key Con
SimpliciTI™ Sy
BlueRobin™ Heart Rate S
Wireless Upda
Abo
He
Only use this update function with watch firmware that allows to invoke the Wireless Update on the watch again.
Older eZ430-Chronos kits require a manual software update of the watch and access point. See Chronoswiki.
Select the firmware file that you want to download to the watch:
s Watch/Applications/Recovery_ez430_chronos_datalogger_915MHz.txt
Browse...
Update Chronos Watch
Progress
Important: If the wireless update fails during the firmware download to flash memory, the watch display will be blank and the watch will be in sleep mode. To restart the update, press the down button.

Figure 6 - eZ430-Chronos Control Center Wireless Update

Lab1: Pairing Chronos and Laptop PC:

16) On Laptop PC: Activate pairing by clicking on "Start Access Point".

17) On Chronos: Select "**SYnC**" by pressing the "**#**" button

18) On Chronos: Initiate pairing by pressing the "DOWN" button
(to activate the selected SYnC mode)
After a short time, the link is established (the **)))** symbol should flash continuously…)

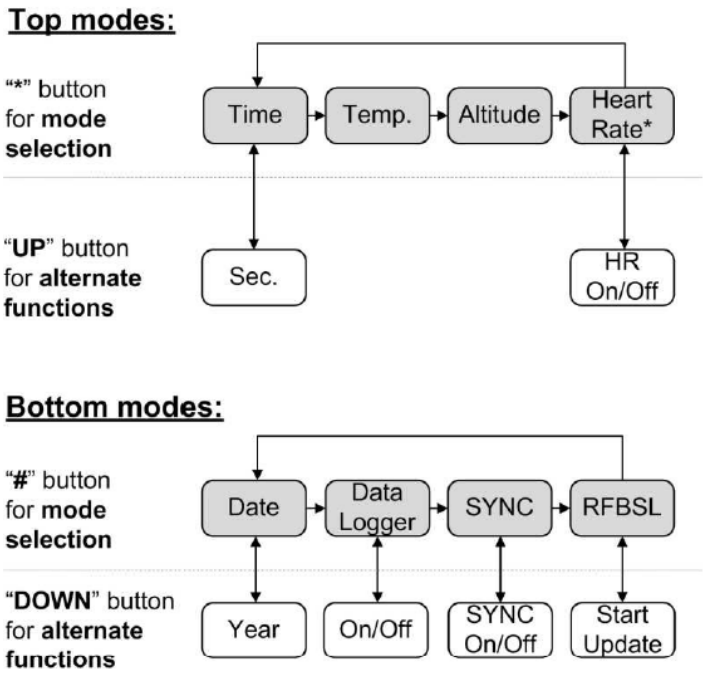


Figure 7 - eZ430-Chronos Data Logger Feature Overview and Menu Structure

19) Enter data to calibrate sensors:
- click-on Imperial Units
- for Data Log Mode check Temperature and Altitude
- enter Temperature and Altitude calibration vales (approximate is ok)
- set datalog interval to 1 sec.

20) Set date and time values using the provided drop-down lists

21) Click "Set Watch" to transfer data to watch, the watch shows "**donE**"

22) Press the "DOWN" button on watch to end the SYNC connection

23) Press the "#" button 3 times to advance from SYNC mode to DLOG mode

24) Press the DOWN button to commence datalog capture, a **(R)** symbol should appear on Chronos screen indicating that it is recording, allow data capture to continue for approximately 15 seconds then again press the DOWN button to end the datalog.

25) On Chronos: Press "#" button once to return to Select "**SYnC**" mode

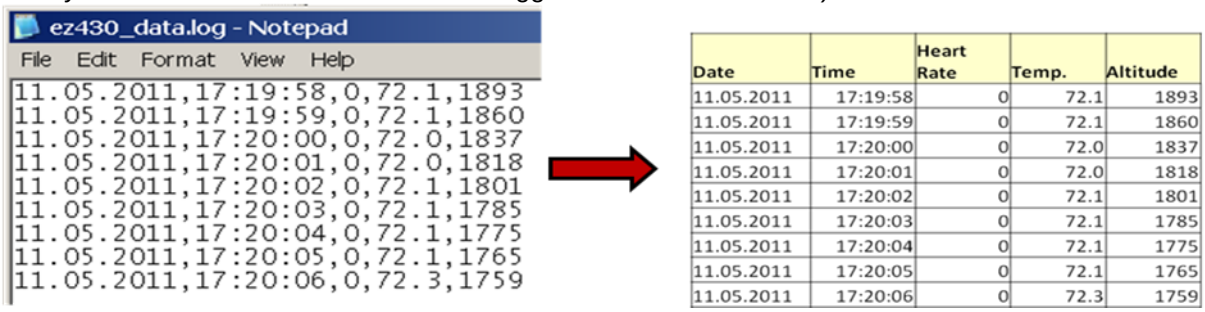
26) On Chronos: Again pair with Laptop PC by pressing the "DOWN" button,
(the **)))** symbol should flash continuously…)

27) Specify (Save data to) file name (DataLog1.csv) and location to store the log file then
Click on "Download" to start data transfer

28) On Chronos: push the "DOWN" button to stop connection when the transfer has finished.

29) On PC: Open the saved file (DataLog1.csv) in a text editor or Excel.

Log file is stored in CSV format. Its content appears as one line per log, each line starts with date, time, heart rate, temperature, and altitude. Parameters which were not logged are set to zero (according to what you set in the eZ430-Chronos Data Logger PC console software).



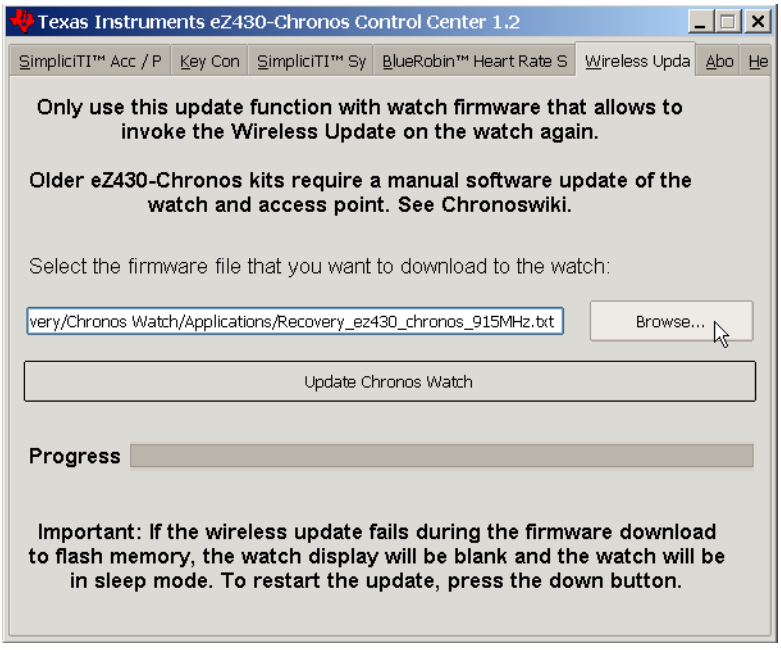
Date	Time	Heart Rate	Temp.	Altitude
11.05.2011	17:19:58	0	72.1	1893
11.05.2011	17:19:59	0	72.1	1860
11.05.2011	17:20:00	0	72.0	1837
11.05.2011	17:20:01	0	72.0	1818
11.05.2011	17:20:02	0	72.1	1801
11.05.2011	17:20:03	0	72.1	1785
11.05.2011	17:20:04	0	72.1	1775
11.05.2011	17:20:05	0	72.1	1765
11.05.2011	17:20:06	0	72.3	1759

Figure 8 - Example data log read-back from Chronos

Lab1: RFBSL Wireless Firmware Update

(optional, not required! For eg. restoring default Sportswatch application without proceeding to Lab2)

30) **Optional**: On Laptop: From **Chronos DataLogger** (OR **Chronos Control Center)** application select the **Wireless Update** tab, then **Browse** to:
C:\Program Files\Texas Instruments\eZ430-Chronos\Recovery\Chronos Watch\Applications
Select **Recovery_ez430_chronos_915MHz.txt** then click **Update Chronos Watch**


Texas Instruments eZ430-Chronos Control Center 1.2
SimpliciTI™ Acc / P
Key Con
SimpliciTI™ Sy
BlueRobin™ Heart Rate S
Wireless Upda
Abo
He
Only use this update function with watch firmware that allows to invoke the Wireless Update on the watch again.
Older eZ430-Chronos kits require a manual software update of the watch and access point. See Chronoswiki.
Select the firmware file that you want to download to the watch:
very/Chronos Watch/Applications/Recovery_ez430_chronos_915MHz.txt
Browse...
Update Chronos Watch
Progress
Important: If the wireless update fails during the firmware download to flash memory, the watch display will be blank and the watch will be in sleep mode. To restart the update, press the down button.

Lab 2A: Chronos 2 Chronos Communication

Lab 2A - Firmware re-compile for Chronos2Chronos communication
Lab 2B - Use of SmartRF Studio to re-configure CC430 RF settings
Lab 2C - RSSI Power Meter

Objective:

- Working in pairs, set your assigned RF channel by editing source code with CCS
- Compile & Download to Chronos
- Link & find your partner…

Notes:
ISM band is used, channel spacing is 200kHz, for our purpose users are 5 chan apart (1MHz spacing):

- USA 915 MHz (902–928 MHz)
- EUR 868 MHz (Europe version of Lab2 allocates channels in the range 870–899 MHz (permissable only for test purposes)

Lab 2A: Chronos disassembly and Lab procedure:

1) Press down screwdriver firmly when unscrewing to prevent stripping!

2) Pry against edge of the eZ-connector to lift the PCB out

3) The battery should **not** be removed from the battery holder for these labs !!!
(On TI's advice we can disregard the warning label for the relatively short duration of this workshop)

Figure 9 - Chronos Disassembly

* Optional Battery Replacement Procedure (after workshop):
If interested in replacing the battery, view the provided video before attempting this…
Chronos Disassembly & Reassembly Video:
http://www.youtube.com/watch?v=WDL3awjhLpw

Lab 2A: Hardware and Project Setup

4) Connect the unpackaged Chronos module to the eZ430 USB Emulator. Laptops with vertically orientated USB connectors will require a short USB extension cable
ie. Standard Male (type-A) USB Plug to Female (type-A) USB Socket
(- alternatively the laptop can be raised by inserting a book below it…)

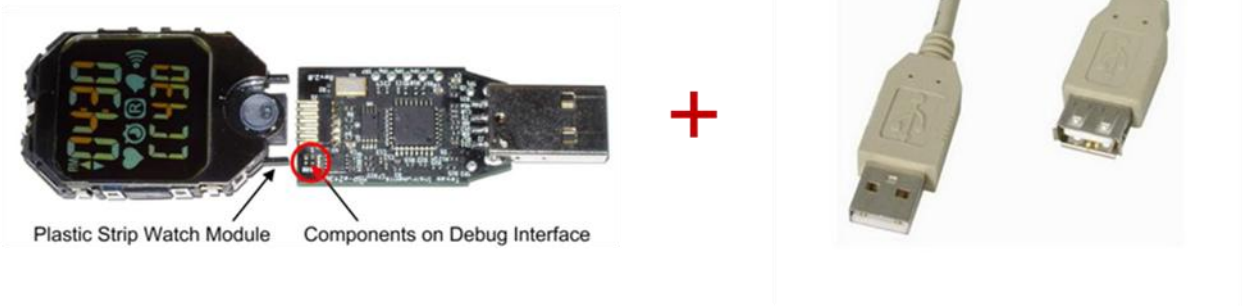


Figure 10 - Chronos attached to Emulator and USB Extension

5) Now plug the eZ430 USB Emulator into the USB port of Laptop PC.

6) On the Laptop, in File Explorer: Copy and unzip the provided files:
Lab2AB_Chronos2Chronos.zip and
Lab2C_RSSI_PowerMeter.zip to your **C:\TEMP** folder

7) Open CCS4

8) File > Switch Workspace > **C:\TI_workshop\Workspace** [click ok]

9) Close the Welcome panel, Close the Grace panel

10) Import Project

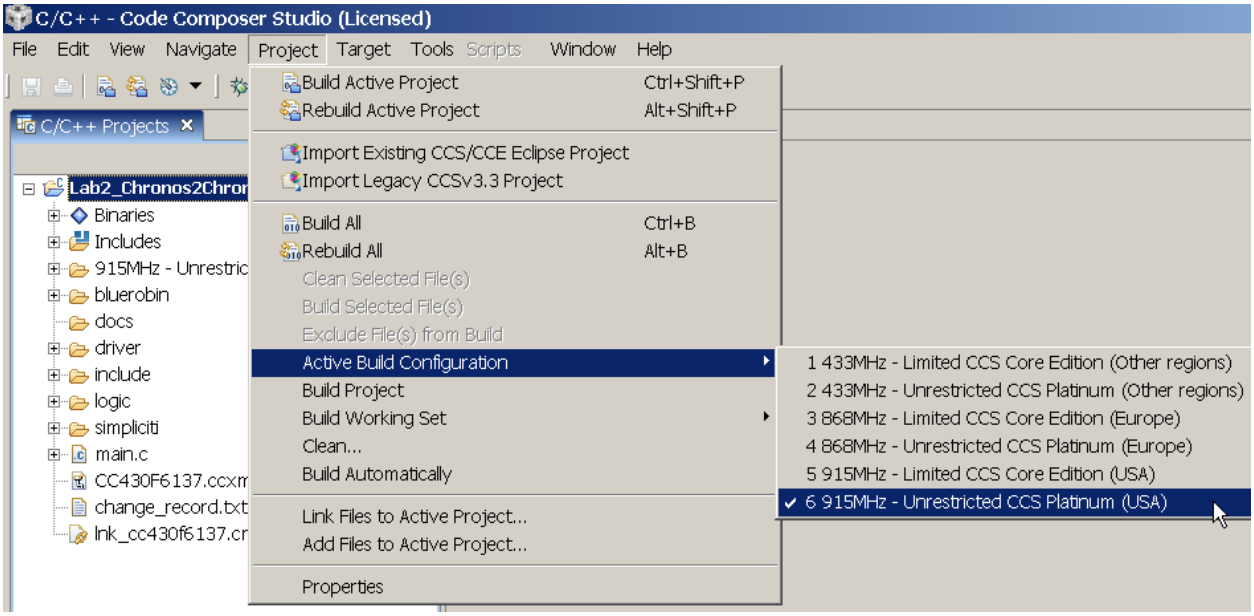
11) Project > Import Existing CCS/CCE Eclipse Project

12) Select **C:\TEMP\Lab2_Chronos2Chronos** project
(ensure “Copy Projects into Workspace” checkbox is checked)

13) Click Finish to import…

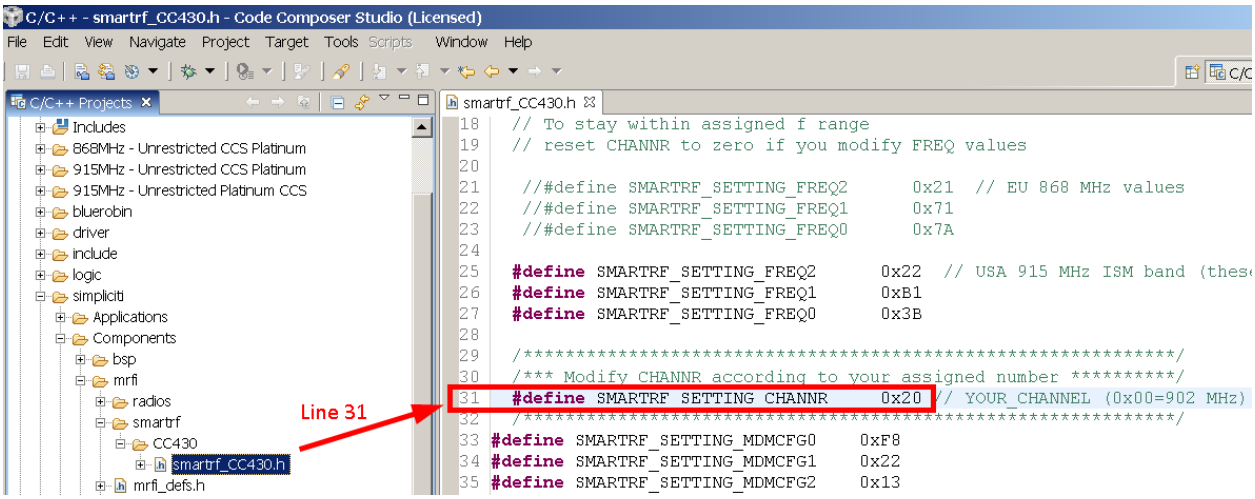
14) Right Click on project name **>** “Set as Active Project”, next

15) Select **‘Active Build Config’:** 915MHz - Unrestricted CCS Platinum (USA)



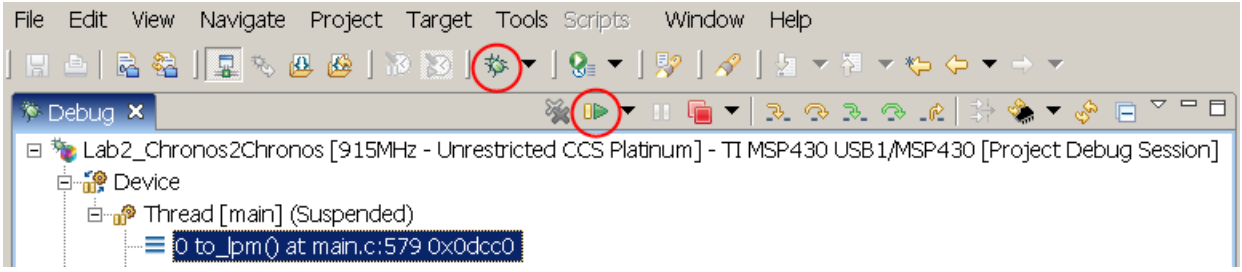
16) Open **smartrf_CC430.h** in editor, make the changes below to **line# 31** based on the **Channel number** in your specific **handout**

17) (Only two of you will be on same channel)



18) In CCS: With the top-level of the project highlighted, do a Build All (**Ctl+B**), this may take a few minutes the first time you build.

19) In CCS: using the circled menu icons select Debug then Run to re-program the flash


File Edit View Navigate Project Target Tools Scripts Window Help
Debug
Lab2_Chronos2Chronos [915MHz - Unrestricted CCS Platinum] - TI MSP430 USB1/MSP430 [Project Debug Session]
Device
Thread [main] (Suspended)
0 to_lpm() at main.c:579 0x0dcc0

20) In CCS: Stop debugging and unplug Chronos from Emulator Board

21) On Chronos: Press the UP button to wake-up the display

22) Bottom Menu displays "**C2C**"

23) Press "**v**" (lower-right button) to turn on RF transmission

24) Press "#" (lower-left button) to increment your partner's Chronos counter

25) If your Chronos counter changes then your partner is pressing his Chronos button

26) Winner: Find your partner and then yell "Chronos!"

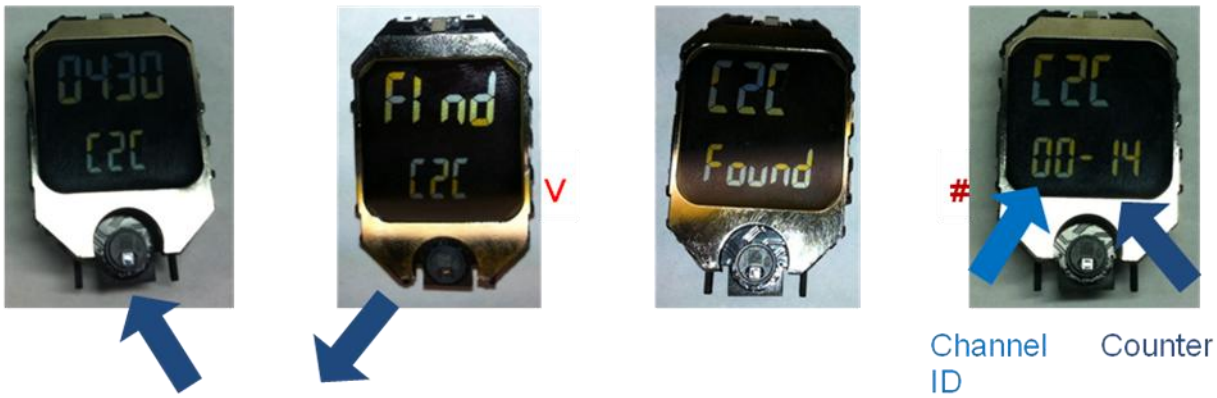
Chronos2Chronos Interaction Summary

1. Bottom Menu: "C2C"

2. Link w/ Partner: Press "v" button

3. Connected

4. Inc Partner's Counter: Press "#"



Lab 2B: SmartRF Studio + Chronos

In CCS: we changed the RF settings manually

- CHANNEL: simple, manageable
- Frequency, modulation, filtering: user's guide

In Smart RF Studio: Change RF settings automatically

- Fully configure your system
- Instantly verify your settings with connected devices
- Template & code generation

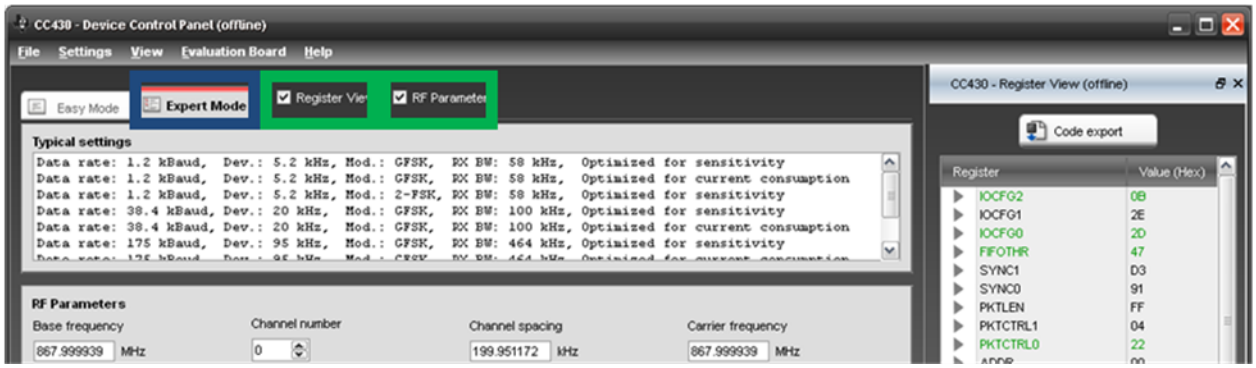
What is SmartRF Studio-7 ?

Smart RF Studio is a Windows App that lets customers evaluate, test and configure Low Power RF devices from Texas Instruments. It is particularly useful for generating chip-specific register values and for finding and fine-tuning RF parameters. It may be used standalone or together with applicable Eval Boards

Smart RF Studio 7: Configure Register View

1) Open SmartRF
   - Right click on CC430 and open **in off-line mode**

2) Configure Register View
   - Select View → **Expert Mode**
   - Enable checkboxes
     - **Register View**
     - **RF Parameters**

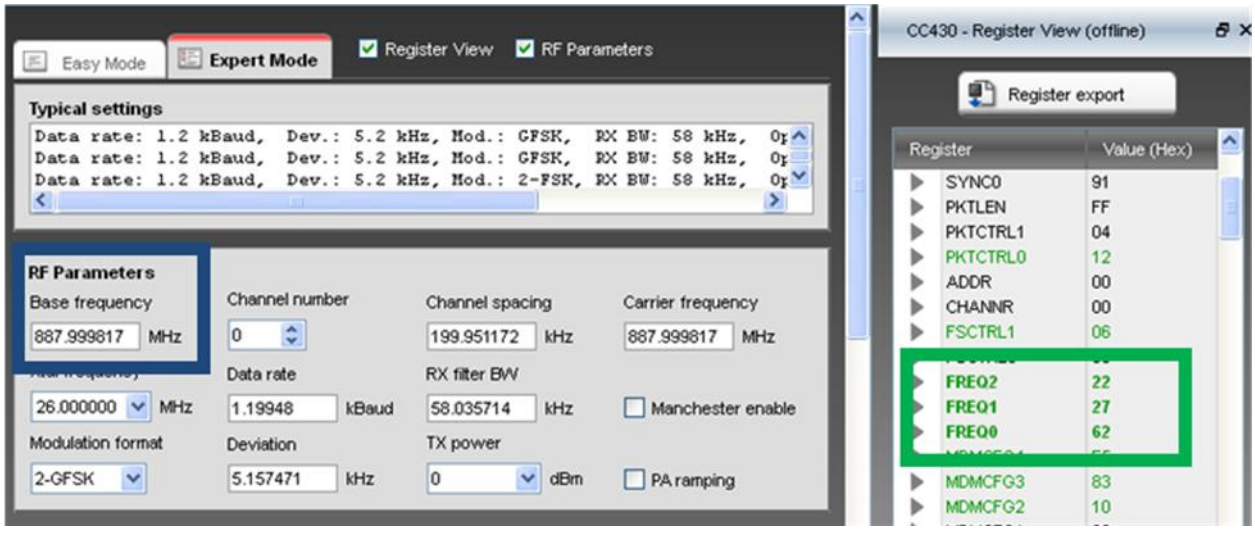

CC430 - Device Control Panel (offline)
File Settings View Evaluation Board Help
Easy Mode
Expert Mode
Register View
RF Parameters
Typical settings
Data rate: 1.2 kBaud, Dev.: 5.2 kHz, Mod.: GFSK, RX BW: 58 kHz, Optimized for sensitivity
Data rate: 1.2 kBaud, Dev.: 5.2 kHz, Mod.: GFSK, RX BW: 58 kHz, Optimized for current consumption
Data rate: 1.2 kBaud, Dev.: 5.2 kHz, Mod.: 2-FSK, RX BW: 58 kHz, Optimized for sensitivity
Data rate: 38.4 kBaud, Dev.: 20 kHz, Mod.: GFSK, RX BW: 100 kHz, Optimized for sensitivity
Data rate: 38.4 kBaud, Dev.: 20 kHz, Mod.: GFSK, RX BW: 100 kHz, Optimized for current consumption
Data rate: 175 kBaud, Dev.: 95 kHz, Mod.: GFSK, RX BW: 464 kHz, Optimized for sensitivity
RF Parameters
Base frequency
867.999939 MHz
Channel number
0
Channel spacing
199.951172 kHz
Carrier frequency
867.999939 MHz
CC430 - Register View (offline)
Code export
Register
Value (Hex)
IOCFG2 0B
IOCFG1 2E
IOCFG0 2D
FIFOTHR 47
SYNC1 D3
SYNC0 91
PKTLEN FF
PKTCTRL1 04
PKTCTRL0 22

3) Align with the partner you just found on a new frequency

4) Note: This must be within your assigned frequency range

5) Change to your assigned RF **base frequency**

6) Notice the **changes** in the register view

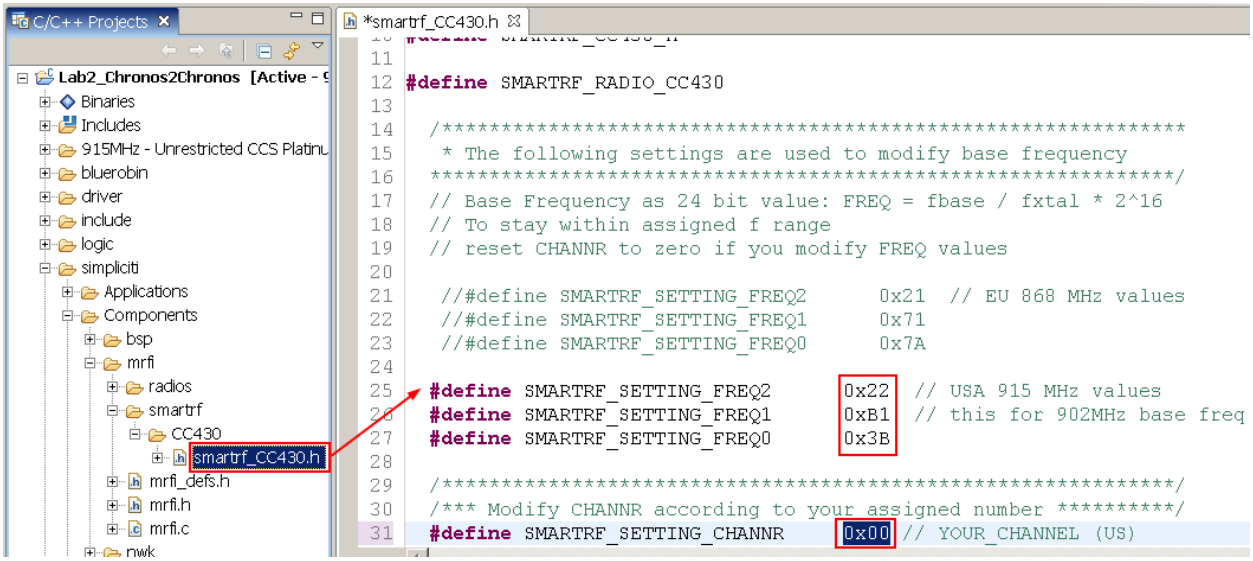


7) In CCS: Open file **smartrf_cc430.h** again

8) Find the three #define lines for FREQ (Lines 25 – 27)

9) Copy new Hex values from SmartRF to the appropriate lines

10) Reset the previously edited SMARTRF_SETTING_CHANNR to **0x00** (Line 31)



11) Recompile, download & run the project

12) Stop debugging and unplug your Chronos

13) Use the Chronos2Chronos menu again

14) Help your partner

15) Make sure you are using the frequency band assigned to you
[check the handout sheet]

16) Can you see similar results? [Yes]

17) Are you still able to connect to your partner? [Yes]
In the first section (Lab2A) we modified the channels.
In the second section (Lab2B) we modified the base frequency and kept the channels to zero.
In both cases you should see similar results and connect with your partner.

Lab 2C : Chronos RSSI Meter

Objective:
- Instructor broadcasts carrier freq. of **906 MHz** (chan# 20)
- Students measure RSSI on their Chronos units
- RSSI value is observed for changes as distance between transmitter and receiver is increased (and obstructions/ interference introduced into the signal path)

Add RSSI Power Meter to Menu

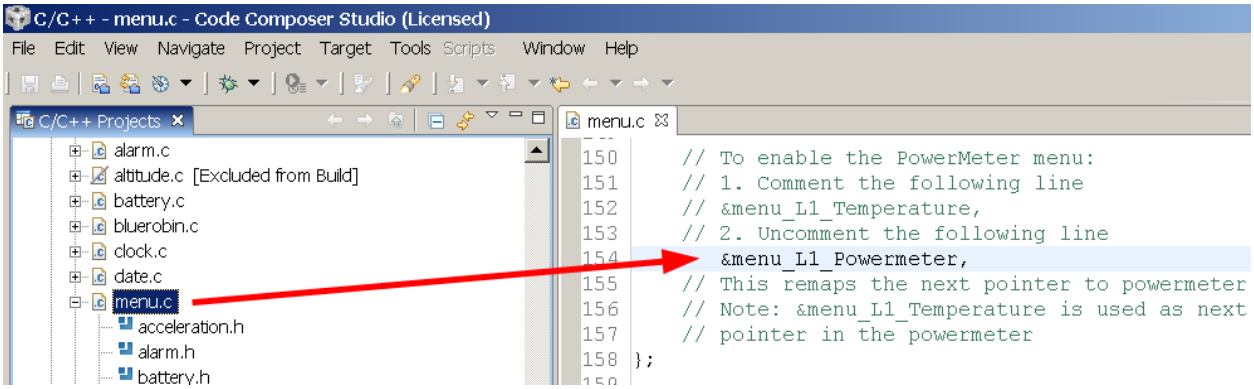
1) In CCS4, close **Lab2_Chronos2Chronos** project

2) Import the **Lab2c_RSSI** project and Open
   - Project > Import Existing CCS/CCE Eclipse Project
   - Select C:\TEMP\Lab2C_Chronos2Chronos project (ensure "Copy Projects into Workspace" checkbox is checked)
   - Click Finish to import…

3) Right Click on project name > "Set as Active Project"

4) Select 'Active Build Config': **915MHz - Unrestricted CCS Platinum (USA)**

5) Open **logic\menu.c** source file in the CCS editor…



6) In menu.c:
   Verify line# 152: **&menu_L1_Temperature** is commented-out
   and line# 154: **&menu_L1_Powermeter**, is uncommented to map "Powermeter" as the next menu-item pointer.

7) Recompile, Download and Run …

8) **Instructor only!** Top Menu: Press "*****" (top-left button) to step through the menu, go an additional step past "**rSSI**" to "**trAn**" (for transmit)

9) **Instructor only!** Top Menu: Press "**^**" (top-right button) to turn on the transmission

10) **Instructor only!** Instructor's Chronos LCD displays:
    - "**906**" (Chan# 20, Tx Freq in MHz)
    - animated Beeper/Wireless icon

Key to Top Menu:
rSSI = for **R**eceived **S**ignal **S**trength **I**ndicator (in dBm)
trAn = for transmit (this for instructor's Chronos only!)

11) Top Menu → Cycle to "**rSSI**"

12) Press "^" → Turn on "**rSSI**" (to start RSSI measurements)

13) Student's Chronos LCD displays:
    - received power level in dBm (eg. "**-43**")
    - animated Beeper/Wireless icon

14) Move Chronos units apart, experiment with metal shielding and other obstructions, (eg. if the transmitter turned ON/OFF your Rx RSSI reading will change from around -40 dBM to -100 dBm (when Chronos units 12 inches apart)

15) What range of RSSI values do you see?

16) Press "**^**" again on both units to Stop transmission and measurement

17) Move closer/away from CC430EM to see differences in reading

Comments:
Instructor's CC430 is broadcasting
- Continuous RF carrier @ 906 MHz

Student's Chronos measures power
- @ 906 MHz (with 400 kHz filter)

The dBm reading changes with
- Distance
- Interference / obstacles
- Antenna radiation pattern / characteristic

Labs: Part 2 Conclusions…

Lab **2A**:The Chronos2Chronos application was edited (for selection of specific RF channels within designated ISM band), then re-compiled and executed for peer to peer SimpliciTI communication

Lab **2B**: Provided a brief insight into use of SmartRF Studio 7 software tool to re-configure the CC430 RF settings

Lab **2C**: Implemented a simple RSSI power-meter application on Chronos.

Appendix: Re-flash of Chronos back to default "Sportswatch" application

Instructor only! When transitioning from Lab2 to the Demos, the instructor will need to re-flash his Chronos back to the default "Sportswatch" application.
(It is recommended that workshop attendees also be familiar with the 3rd party tool for this).

The easiest method to reprogram Chronos is using **BM Innovation's Firmware Update Tool**.
(from the **eZ430-Chronos Watch Firmware Update Tool.exe** download)

Again reprogramming the MCU's flash memory using the FET debugger/programmer dongle, this tool writes the wireless updater into BSL memory of the watch and programs the corresponding SportsWatch recovery firmware according to latest eZ430-Chronos release)
The script to select is: **915MHz_Firmware_Update_1_5.bmt**

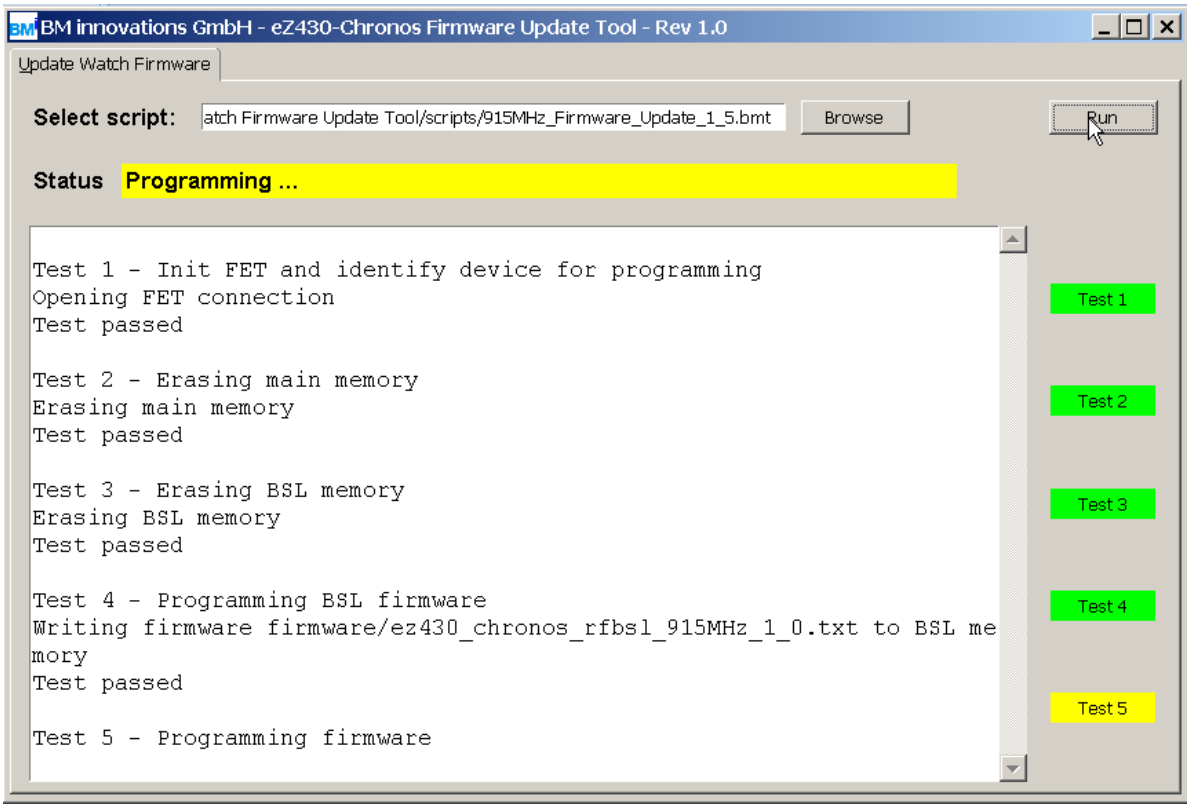


Figure 11 - BM Innovations Firmware Updater Tool re-programming Chronos

Getting Help and Support

TI Page	http://focus.ti.com/docs/toolsw/folders/print/ez430-chronos.html
wiki:	http://processors.wiki.ti.com/index.php/EZ430-Chronos
GoogleGroup:	http://groups.google.com/group/ti-chronos-development-/topics
E2E:	http://e2e.ti.com → MSP430 Microcontroller Forum